

need a boost but don't have the confidence to ask for it; we should take the initiative in reaching out.

The onus of mentorship does not have to lie solely on professors, however; other resources can be utilized for the benefit of all parties. For example, colleague Joy Zhou and I recently began a mentoring program for female and non-binary mathematics majors in our department that draws upon the expertise of our alumni base. Students are grouped into peer clusters with whom they meet monthly, in order to establish a group on campus from which they can draw support on a daily basis. Additionally, each student receives an alum mentor with whom they connect several times each year. Since they rotate mentors each year, each student participant graduates with several alum connections that they can call upon for advice and encouragement later in their journey. These mentor-mentee relationships have been invaluable to all groups: several students have received job offers as an outgrowth of discussions with their mentors, alum mentors often express appreciation for the opportunity to get involved with their old department, and all of our program participants get to explore numerous career paths about which we, as professors, are often unable to advise them. In particular, such a mentoring program built with a focus on supporting underrepresented groups in STEM fields can help to address the leaky pipeline, by providing students with frequent validation and giving them a group of peers and role models with whom they self-identify [L1]. Because members of minority groups may be somewhat shielded from the worst effects of bias during their time at PUIs, it can be particularly important for them to have an existing support structure in place when they inevitably encounter these prejudices later in their careers.

For all the benefits that a formal mentoring structure provides, however, informal check-ins can have just as large of an impact and often require a much smaller time commitment. The relationship need not have been a close one during the student's time at the college in order to make a difference. Pacheco-Tallaj has written in this very publication about the disproportionate impact that small gestures—even one-time conversations—can make from the perspective of undergraduate students [L2]. Simply sending a quick email to a former student can make them feel seen and reopen the lines of communication, in the event that they are struggling but hesitant to reach out on their own. Many times, during my own graduate school years, a short check-in email from a previous REU advisor reinforced that I did belong, and reminded me of a time in my undergraduate years when I was passionate and enthused about mathematics...

...Which brings me back to 2011. Here I was, in the first year of my graduate program, and already looking for an escape route. While emailing back and forth with a student who was still at my former college, I casually mentioned that I was considering quitting. I certainly didn't expect

anything to come of that remark. But I was wrong. This student immediately sent out an SOS to the math department. She handmade a beautiful card and marched it around to all of my former professors, who covered it in encouraging notes, anecdotes, and reminders of those moments during my undergrad journey when I had experienced breakthroughs and successes as a result of hard work. The card arrived in my mailbox a week later, and it made all the difference. Having this reminder of where I came from and how many people were in my cheering section gave me the motivation to keep pushing forward. I made it through those difficult first few years, found myself a new group of supportive peers and a thesis advisor, and finished my PhD in 2016. I'm now working in my dream job as a professor at another PUI.

I still have that card. It serves as a reminder of the kind of professor I want to be.

### References

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## Maintaining a Research Career at a PUI

*Jennifer Paulhus*

My tenure track job search over a decade ago can best be described as "scattershot." As a postdoc during the height of the financial crisis, I applied to just about any job I was

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remotely qualified for. Teaching load? I was flexible. Part of the country? Almost anywhere was fine. (Sorry, not sorry, NYC. I don't do well in major metropolitan areas.) Did the job specify an algebraist? I'm an *algebraic* number theorist. You need a geometer? I'm an arithmetic *geometer*. Topologist? Curves are Riemann surfaces. Math biologist? Ok, I didn't apply for those jobs.

Because of this broad application process, I found myself at a PUI rather coincidentally, instead of as an intentional career choice (well, and Grinnell College solved a 2-body problem). But in the intervening decade I've come to appreciate many unexpected things about a career at a PUI. In particular, one of the beautiful things about working at a PUI is the flexibility in what a successful career can look like. Some faculty members at Grinnell focus on the scholarship of teaching, others focus on service or even leadership. Still others prioritize student research. For me, research has always been an important part of my mathematical identity and I wanted to find ways to maintain a research career while developing as an excellent teacher and dedicated colleague.

I've taken advantage of the invitation to write this essay to reflect on what aspects of my career have helped me be successful as a researcher while balancing the demands of working at a PUI. I have settled on two components of my career which seem to be the linchpin for my continued research progress, and I hope articulating them here will give other faculty members ideas for how to continue a strong research career at their own PUI. I'm not going to talk about how to do enough research to get tenure, or how to find time to do research. There are many resources out there that give good advice about both of these issues, and any advice about either concern is highly dependent on the particular institution and the particular person.

I do want to pause here to acknowledging my privilege of working at a PUI which also happens to be a highly selective, private college with strong financial resources. Grinnell College is generous with funding to support faculty scholarship and research leaves/sabbaticals which have helped remove some barriers to doing research.

### Develop a Skill That Makes You Indispensable

By my second or third year at Grinnell it became clear that it was untenable for me to maintain a long-term research *program* in the areas I was trained in. Students often choose to attend PUIs because they want to have strong relationships with their professors. That desire exacts a heavy toll on faculty members' time. We spend countless hours getting to know students and helping them on their journey (in addition to typically high teaching loads). Thus my research time happens in fits and starts. Some semesters my teaching duties are all consuming. Other semesters additional service is necessary. There isn't consistent time to regularly scour arXiv to keep up with all the latest work in my field. There isn't the right kind of time for me to just sit with the

research and plan where it might go. If I have two weeks at the beginning of January to squeeze in some research, I want to be actively doing research, not planning.

At PUIs there are usually no graduate students, nor any postdocs. There is no one else in my field in my department. And because of where I live, there is no one in a closely related field within at least an hour drive. This all means I don't have a built-in research team. We do have wonderful undergraduates who can do amazing work, but the level and types of problems my students typically work on doesn't quite scratch the same itch as working on deeper open problems

Instead of trying to create my own research program from scratch, I have become an indispensable part of several research teams. The word "team" here is important (math is best done with others!), but I'm going to focus on the word "indispensable". I have a lot of experience and expertise in coding and algorithms. (Thanks, Mom and Dad. That Apple IIe you brought home in 1984 and which booted up with a BASIC prompt started me down this path.) In projects I've been involved in, I am typically the person writing code to test conjectures or search for examples. I've taken ad hoc methods and turned them into algorithmic processes allowing for computations of many examples en masse, which lead to even more conjectures. I've also worked to make the data generated from those searches available for mathematicians who might not be comfortable with coding themselves. Of course, I brainstorm and prove things and write up results just like everyone else in the group, but the coding is what makes me indispensable.

Besides your content knowledge in your research area, find something that makes you indispensable to a larger group. Are you good at clever manipulations? Do you excel at doing literature searches to find an essential result? Does your expertise sit at a unique intersection of different mathematical fields so you can be the bridge between those areas? Are you good at checking every detail of an argument? Are you good at writing up results so that they are easy to follow? At most PUIs, you don't have to be the person with the big vision in your field. You can make profound contributions to research teams by bringing something essential others may not bring.

### Let Your Research Career Wander a Bit

The original problem my PhD adviser proposed to me involved studying Jacobian varieties over finite fields. After making some modest progress, I gave a talk at a graduate student conference. A professor from another university who happened to be in the audience said to me, "What you are doing is fine, but here is a more interesting question." And suddenly I found myself working on covering spaces and the moduli space of curves, neither of which I had prior training in.

Depending on the PUI you work at, "publish or perish" may not be a relevant phrase. It is often OK to take a risk

and shift research focus if the opportunity arises, because high paper counts are often not so important. Maybe you want to move to a field with more undergraduate research opportunities. Maybe a new emerging field is particularly interesting. Maybe you recently discovered a connection between your prior research and another area of mathematics. Working at a PUI may afford you the space to wander in your research which, at least from my experience, has led to a much richer research career.

During my first year at Grinnell, I got an email invitation out of the blue from a mathematician in Chile, Dr. Anita Rojas. She had found out about my research from an anonymous referee who had pointed out similarities between her research and mine, and she had some funding to invite other researchers to Chile. Despite not speaking Spanish and never having been on a plane flight over four hours, I took her up on the offer. That was the beginning of my major ongoing collaborations with the Geometry at the Frontier research group in Chile.

So wander geographically as well. There is beautiful mathematics being done all over the world and such opportunities may come from unexpected places. That one trip to Chile led to further invitations, and even a three-month visit this past spring through the Fulbright program. None of those opportunities would have been possible if I hadn't been willing to try a new, unexpected research opportunity. Accept invitations whenever possible even if they involve long flights to places that you have no familiarity with. (And, my eternal gratitude for the anonymous referee who connected our research.)

A research career at a PUI probably won't look like a research career at a major research university, but that isn't necessarily a bad thing. Mine has been helped along by having a particular skill which I can bring to different research teams, and a willingness to try different areas of mathematics (often arising in serendipitous ways). Both of these approaches might have stymied my career if I had been at a major research university, but at a PUI they've helped my research flourish.



Jennifer Paulhus

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## Analysis and Differential Equations at Primarily Undergraduate Institutions

*William R. Green and Katharine A. Ott*

Analysis and Differential Equations at Primarily Undergraduate Institutions (PUIs) is an umbrella title that encompasses a set of professional development activities that we have initiated over the past three years. In this article, we'll detail the work that we've done to date with the hope that others will join us or create similar initiatives. Ultimately, we would like to bring more visibility to the varied and excellent body of mathematical work coming from faculty at PUIs and to create long-lasting networks to combat the feelings of professional isolation. For early career faculty who work at primarily undergraduate institutions, we want to emphasize the importance of building a variety of professional networks.

The idea for these activities began in 2019 over lunch at the JMM in Baltimore. We were inspired by an AMS Special Session focused on number theory at undergraduate institutions. We thought it was a great idea and we wanted to see something similar for our own research area of analysis and differential equations, so we organized a Special Session in 2020 under the name of Analysis and Differential Equations at Undergraduate Institutions. Since this initial Special Session, there have been four similar AMS sessions, altogether featuring more than 30 speakers from PUIs. We also organized a series of virtual panels in Summer 2021 focused on various categories of professional development: supervising undergraduate research, maintaining an active research program, avenues for professional growth, and how to best prepare students for future study and careers, all through the lens of analysts working at PUIs. Finally, we have a message board hosted by MAA Connect for members to communicate online.

### Recognizing a Need

We feel strongly that there is a need for these types of professional activities tailored to professionally active faculty at PUIs. There is a wealth of research-focused programs that include cohort building and professional development run through the AMS and the math institutes. These programs are often targeted toward or attract mainly mathematicians from R1 institutions. Simultaneously, the Mathematical Association of America (MAA) runs great professional

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